Ontario
Ministry of
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Occupational
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Occupational Health in Ontario

Volume 4, Number 2, April 1983

Health Effects—Monitoring the Work Group

Comparison of Industrial Risks

Work Practices to Reduce Heat Strain

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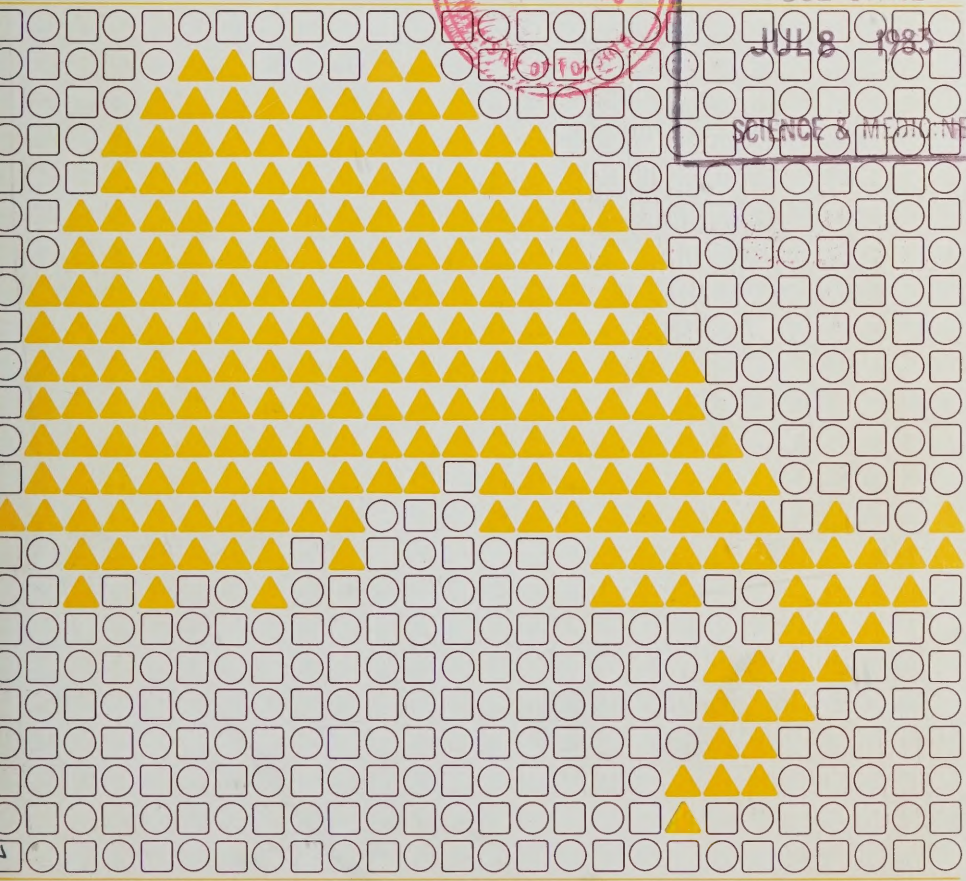

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Occupational Health in Ontario

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3. Gamble JF, and Battigelli MC. Epidemiology. In: Clayton GD and Clayton FE. eds. Patty's industrial hygiene and toxicology. New York: McGraw Hill, 1978: Vol 1; 113-116.

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T.W. Anderson, M.D.

Health Effects — Monitoring the Work Group

Summary

Despite our efforts to provide a safe working environment, it is always possible that the effect of chemicals or other environmental hazards may differ in human beings from what is predicted in laboratory experiments. It is therefore prudent to monitor the work force to ensure that any abnormal pattern of illness or cause of death will be detected as soon as possible. This epidemiological approach is necessary because the onset of a certain disease in an individual cannot automatically be ascribed to occupation unless the disease never occurs in the normal population. In fact, most of the diseases with which we are concerned do occur in the normal population and we end up looking for differences between the frequency of occurrences within a particular group of employees and that seen in unexposed people.

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Ideally, we should be able to predict the effect of any occupational environment on the basis of laboratory tests involving animals or other biological models. In practice, however, we may be inaccurate in our predictions of the effect in the human species. Furthermore, even if the nature of the effect is predictable, we may have a wrong idea of the size of the effect for a given dose.

There have been several examples of occupational exposures that were originally considered safe, but ultimately turned out to have unexpected harmful effects. Occasionally, the harmful effect is so unique, e.g. silicosis, that it is identified quite speedily since the condition does not occur 'naturally' in the general population. Usually, however, the effect seen is an increase in the frequency of a disease such as cancer that occurs in the general, unexposed population. Under these circumstances, unless the increase in the frequency of the disease is very large it may be many years before it is realized that a particular group of employees is experiencing an abnormally high frequency of disease or death from a particular condition. For this reason it would seem prudent for any company that is involved with potentially toxic situations to monitor the health experience of their employees both during their working life and on into their pension years. Somewhat surprisingly, in view of the great interest in occupational health in the last few years, there are still very few industries that do, in fact, carry out such long-term surveillance and it should be a matter for some local pride that Ontario Hydro is one of the very few companies in North America that do this. Indeed, in terms of surveillance of nuclear workers, Ontario Hydro was the first organization in the entire world to adopt routine long-term mortality surveillance of its employees.

Ionizing radiation is an example of an environmental hazard that has well-defined effects. But estimates of the health effects of low levels of ionizing radiation are based mainly upon animal experiments and upon human experience at high doses over relatively short periods of time.

*Presented at the Ontario Hydro Health and Safety Conference, November 9, 1981.

Although it is generally believed that extrapolation in a linear fashion down to zero dose from these high doses is a reasonable (and, if anything, conservative) way of estimating the effect of low doses, there is still controversy over this interpretation and some scientists believe that we may be underestimating the dangers of low level radiation. For this reason, it is prudent to monitor the mortality experience of nuclear workers.

While long-term health studies of employed populations can become very sophisticated, the basic idea is a simple one. By making use of routinely collected data on active employees and pensioners the number of observed deaths in various occupational categories are compared with what would be expected if the individuals concerned were simply a random sample of the general population. In this case, death rates among the general population of Ontario are used to create predicted values for each group. The calculation of the predicted deaths is carried out on the basis of five-year age groups, and figures are used around the most recent census years (years ending in 1 or 6). For example, in Ontario in 1971, there were 170,400 men aged between 55 and 59. In the five-year period centred on 1971, there was an average of 616 deaths per year from all causes among men aged 55 to 59, which can then be expressed as a rate of 362 deaths per 100,000. If the employee population being studied has 100 men in this age group, one would then predict a fraction of a death (·36) during the year. If the number in this age group was 1,000 then the predicted number of deaths would be 3·6, and so on. Once the predicted figure for each five-year age group has been calculated, the total is obtained for the whole group, over all ages, and expressed as a single predicted number for the employee group of interest. This can then be compared with the observed number of deaths, and the ratio of observed to predicted calculated. This is usually given as a 'Standardized Mortality Ratio' (SMR), this being the percentage of observed compared to predicted after 'standardizing' for the age distribution of the employee group.

A point worth emphasizing here is the importance of standardizing predicted deaths by five-year age intervals rather than by simply using a crude figure for the whole population irrespective of age distribution. The reason for this is that employed groups often differ substantially in their age spectrum from the general population and a distorted figure for the predicted deaths would be obtained. This is particularly true in the case of the Ontario Hydro nuclear employees since, being a rela-

tively young industry, it is heavily weighted with younger men. If age was not taken into account, one would therefore end up with a grossly inflated figure for predicted deaths (since older people have higher death rates) and this would give the nuclear workers an artificially low Standardized Mortality Ratio.

Even with the precaution of age standardization it is usual to find an SMR below 100 in most employed groups. This is known as the healthy worker effect and is due to the fact that death rates based on the entire population include a substantial number of individuals who are physically incapable of obtaining a job. These individuals tend to have a higher than average death rate and therefore push up the general population figures.

The results of the first 10 years of the Ontario Hydro long-term study are shown in the following Table. It may be noted that for deaths from all causes there have been 32 deaths in the nuclear employees compared to a predicted of 58·9, giving an SMR of 54, i.e., approximately half the number of deaths that one would have expected in this group. For neoplasms (cancers), the corresponding figures are: observed 6, predicted 9·7, for an SMR of 62. As can be seen in the Table, the nuclear group are not the only ones that show an SMR below 100. Both the thermal employees and other Hydro employees show SMRs that are in almost every case less than 100. The very low SMR in the nuclear group is almost certainly due to the fact that the 'healthy worker' effect is most marked at younger ages.

At the present time, the comparisons have been conducted on the basis of current or most recent location of employment, i.e. nuclear or thermal generating division or other parts of the Ontario Hydro system. Under active development is a similar type of comparison based on cumulative radiation exposure amongst those employees wearing film badges. This illustrates the point mentioned earlier that this type of surveillance can be carried out in a very straightforward manner for any group of interest. Other groups of interest would include shift-workers, foresters (exposed to herbicide chemicals), etc.

It must, however, always be borne in mind with any occupational comparisons, that it does not necessarily follow that any differences observed are necessarily due to a particular occupational exposure of the individuals concerned. Self-selection into different types of job and the presence in certain occupations of more than one potentially hazardous exposure make it dangerous to

Cumulative Experience 1970-1979

		Nuclear	*Thermal*	*Other*	*Total*
All Causes	Pr	58·9	93·3	1844·3	1996·5
	Ob	32	68	1556	1656
	SMR	*54*	*73*	*84*	*83*
Neoplasms (Cancers)	Pr	9·7	19·3	397·3	426·3
	Ob	6	23	363	392
	SMR	*(62)*	*119*	*91*	*92*
Circulation (Heart, Stroke, etc.)	Pr	16·8	39·1	968·8	1024·7
	Ob	6	27	900	933
	SMR	*(36)*	*69*	*93*	*91*
Accidents (Occupational and non-occupational)	Pr	23·1	19·7	158·2	201·0
	Ob	19	10	117	146
	SMR	*82*	*51*	*74*	*73*
All Other Causes	Pr	9·2	15·3	320·1	344·6
	Ob	1	8	176	185
	SMR	*11*	*52*	*55*	*54*

Predicted (Pr) and observed (Ob) deaths and standardized mortality ratio (SMR) in Ontario Hydro employees, active and pensioned combined, 1970-1979.

SMRs express observed as a percentage of predicted, and have been put in parentheses where based on less than 10 observed deaths.

Predicted deaths are based on Ontario rates between 1971 and 1976.

assume that any distortion of normal health patterns is the result of the single occupational exposure being studied, or, indeed, of the exposure that happens to be the most easily measured. Ionizing radiation is a prime example of this since it can be measured much more easily than most chemical exposures, and therefore may sometimes be blamed for ill effects that are, in fact, due to other environmental factors which have not been recorded with the same accuracy.

In any case, present conclusions on radiation effects in the Hydro nuclear employees must, necessarily, be very limited. The relatively small numbers and the relatively short follow-up period mean that radiation-induced mortality amongst nuclear workers would need to be very large to be detectable at this stage. However, the important point is that the basic information is being collected in an ongoing and simple manner, and this is always preferable to attempting to go back 20 or 30 years to collect evidence in groups that are belatedly discovered to have had an unusual hazard in their work environment.

Concerning the relatively short duration of follow-up, although the majority of the nuclear workers have been exposed less than 10 years, it should be remembered that the latent period for radiation-induced leukemia is thought to be approximately two to five years so that any gross excess of leukemia mortality could be visible even now. Again the emphasis must be on the word 'gross' since small differences from current estimates of dose/response relationships would not be detectable with these numbers. However, some recent studies that have received wide publicity have claimed sensitivities to leukemia of the order of 10 or 100 times the generally accepted levels, and this sort of risk should soon show up if it were true. (The nuclear group currently have a predicted figure for leukemia of about 0·7 and an observed of 0).

Another potential weakness of the present type of study is that persons who leave the industry are not followed up. However, the importance of this source of error should not be exaggerated. In the past, there has been a tendency to claim that simple follow-up studies were not worth doing because of the loss to follow-up of ex-employees, and the result of this has been that virtually no follow-up studies of *any* sort have been done in most industries.

There are really two issues here: (1) the long latent period of many cancers makes it important that employees be followed into their pension years so that late appearing cancers are counted. This is no problem if the company has a pension plan. (2) Does loss to follow-up of those individuals who leave the industry introduce some sort of bias into the conclusions?

That this latter problem can sometimes result in bias is not to be disputed. One classic example is asbestos exposure where the men most severely affected may leave the industry because of shortness of breath and other early respiratory symptoms. Their subsequent development of lung cancer might therefore be missed. However, if we are to believe that a similar sort of bias exists in the nuclear industry then it is necessary to postulate that there exists some sort of early effect of radiation that causes an individual to leave the industry early and is thus lost to follow-up. The implication here is that this hypothetical early radiation symptom is something which is linked to an increased risk of subsequent development of cancer, and while no possibility can be ruled out in science as entirely impossible, I am not aware of any reason to believe that individuals leaving the industry are in some way more sensitive to the carcinogenic effects of radiation than those who stay behind.

Consequently, although the failure to follow up those who have left the industry will result in lower numbers to be studied, it is unlikely to result in bias in the sense of distorting the true dose-response relationship.

As it happens, modern computer technology will, in any case, reduce the problem of loss to follow-up, at least in Canada, since record-linkage programs are being developed which enable a high proportion of working individuals to be identified when death occurs after they have left an industry. This development will ultimately be a very cost-effective way of tracing people, but even with this technique there is need for caution. First, as with any process of this sort, there is, inevitably, a certain amount of inaccurate linkage, both false positives (i.e. some deaths identified that were not, in fact, those of the individuals being followed) and also false negatives (i.e. some individuals being followed who have died, but whose deaths for some reason are missed). The other element of inaccuracy that may be introduced by this method is that persons who have received substantial radiation exposure following their departure from the company under study will not be credited with this radiation dose. There may therefore be some distortion of the dose/response relationships. (Here again, however, future co-ordination of resources may reduce this problem since a centralized national dose record system would avoid this difficulty).

Conclusion

By making use of routine existing data flow, the Ontario Hydro long-term health study enables a surveillance program to be maintained at very low cost.

The main advantage of such a follow up program is that real hazards will be detected as soon as possible. Another value in these days of 'headline hysteria' is that unfounded anxieties about the ill-effects of radiation can be minimized for both employees and their families. It should, however, be emphasized that for this aspect to be truly effective, the process of monitoring must be completely open, with frequent progress reports and a trusting relationship between management, union and scientific personnel. In practice, the very simplicity of the Ontario Hydro system has been a major asset in this regard in that there is a minimum of mystery surrounding the methodology; the calculations can be checked by anyone with a pocket calculator, and most people find it easy to understand the concept of comparing observed and predicted deaths.

Thus, even though the hazards of ionizing radiation are well understood, monitoring of this work group is important to guard against the possibility, however unlikely, that for any given dose our estimate of the size of the effect is erroneous.

Résumé

Malgré tous les efforts que nous faisons pour assurer la sécurité en milieu de travail, il est toujours possible que les effets des produits chimiques ou d'autres risques inhérents á l'environnement puissent être différents chez les êtres humains de ce qui est prévu dans les expériences de laboratoire faites sur les petits animaux ou d'autres modèles biologiques. Il est donc prudent de surveiller les travailleurs pour s'assurer que si une série anormale de maladies ou de décès se produisait, elle soit détectée au plus tôt. Ce genre d'épidémiologie appuyée sur la population est nécessaire parce que l'apparition d'une certaine maladie chez un individu ne peut pas automatiquement être rattachée à son travail, à moins que cette maladie n'apparaisse jamais dans la population normale. En pratique, la plupart des maladies dont nous nous occupons sévissent dans la population normale, c'est pourquoi nous devons étudier les différences de fréquence de son apparition entre un groupe particulier de travailleurs et les personnes non exposées.

R. Wilson, B.Sc. and
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Comparison of Industrial Risks

Summary

Three measures of occupational risk in industry are discussed: fatal accident rate, standardized mortality ratio, and loss of life expectancy.

Information on the differences in occupational risks, along with knowledge of the costs associated with the reduction in the risks, enables rational decisions to be made in the allocation of limited resources.

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Knowledge of the risks that exist across a wide spectrum of industries and specific occupations within industries is important for a variety of reasons: Logically, it should be the starting point for the allocation of resources to correct unsatisfactory situations; it is useful in establishing the norms or standards for acceptable levels of safety; and it could be useful as a guide to workers or those entering the work force on the risks they face in their occupations.

Societal perception of risk is, in some instances, widely at variance with the actual risks that exist. For example, when people were asked to rank the risks from 30 different hazards of modern life, nuclear power was ranked first by members of the League of Women Voters and by college students, and eighth by Business and Professional Club Members; its actual rank was twentieth.[1] The same misperception of occupational risks also exists. There may be a number of reasons for this. Some occupational risks are associated with debilitating or fatal diseases, such as cancer, which are feared because of the extended pain and suffering associated with them. In other cases, the nature of the risk may be difficult to understand, (e.g. radiation). In some occupations, occasional disasters involving large numbers of workers magnify the risks (e.g. underground mining), whereas in other occupations, fatalities usually occur singly (e.g. forestry); in fact, the fatality rate per unit of time worked is higher in forestry than in mining.[2] Regardless of the reasons, it is a fact that the perception of the size of a risk often bears no relationship to its actual size. This is a reality that must be understood and tolerated, if not accepted. This paper attempts to give some perspective on the size and variability of occupational risks.

*Presented at the Canadian Nuclear Association Uranium and Nuclear Issues Seminar, Toronto, November 2-3, 1982

Measures of Occupational Risk

In occupational health and safety, the injury and suffering being experienced by a work force is currently measured in a number of ways. Ideally, the assessment of the total harm being experienced must take into account not only the effect of acute events, such as accidents, but also the detriment from chronic exposure to chemical and physical agents. Summation of such effects may be quite difficult. An added problem is how to combine the harm from occupational accidents which result in fatalities with those which result in injuries.

Normally, this is not attempted and the practice is to employ separate measures for accident fatalities, injuries and occupational disease effects. The International Commission on Radiological Protection[3] has proposed a method of combining the detriment from all types of accidents and diseases. The combined effect has been designated as an Index of Harm. This measure or a similar one may, at some time, become employed in the comparison of occupational risk, but current practice is still far removed from this unifying concept.

In considering the risks of various occupations, fatalities are singularly important as the impact of a fatality is obviously very much greater than the impact of a disabling injury. Beyond this, however, it can be shown that for moderately hazardous industries (greater than 10 fatalities per 10^8 man-hours), the years of life lost from fatalities are even more than the time lost from disabling injuries.[3]

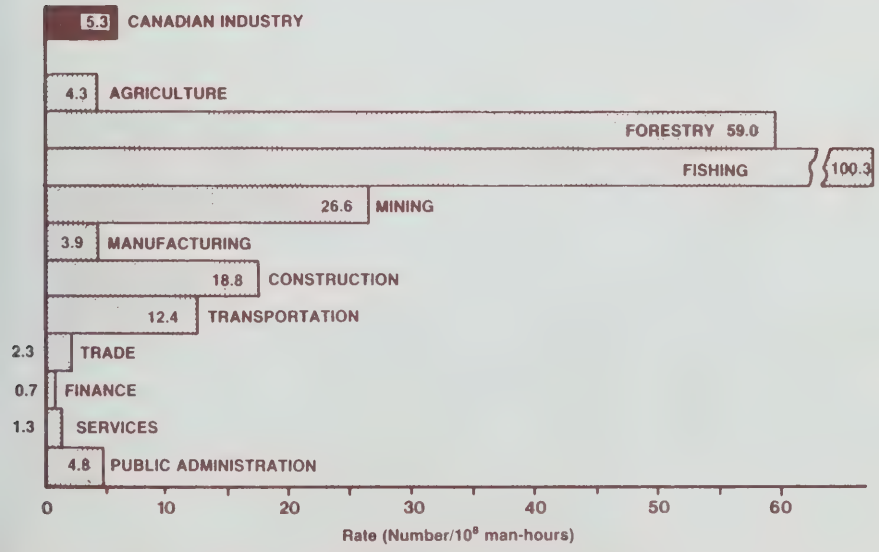
For these reasons, in the comparison of risks of various occupations in this paper, only fatalities from accidents and diseases will be considered. For occupational accidents, the measure employed is the number of fatalities per unit of time worked; for occupational disease resulting from exposure to toxic agents, this unit is not generally usable for a variety of reasons, and the standard method of identifying whether there is an increased risk of death in an occupation is to compute the standardized mortality ratio (SMR) for the occupation. This is the ratio, frequently expressed as a percentage, of the observed number of deaths among the employees in that occupation to the expected, where the expected number of deaths is estimated using an appropriate control population similar in both age and sex distribution. The measures of fatal accident rate and SMR are not directly comparable, but may be related to each other by calculating the average loss of life expectancy (LLE) in both instances.

Fatal Accident Rates in Canadian and Ontario Industries

Despite the importance of fatalities, information on fatal accident rates in industries in Canada and Ontario is not readily obtained. Many safety practitioners prefer to employ disabling injury rates as a measure of performance. This is understandable in small companies where a fatality is a rare event and the fatal accident rate is statistically unsound over any reasonable monitoring period.

Some information on fatal accident rates is available from large companies and from government agencies, such as Workers' Compensation Boards, although surprisingly little analysis of cross-industry fatal accident rates by occupation, for example, is carried out. Figures 1 to 8 present data on fatal accident rates in various industries and occupations in Canada and Ontario. The fatal accident rate of 175 per 10^8 man-hours for demolition workers in Ontario (Figure 3) is worth noting. This means that of 1,000 workers in this trade, 140 will be killed in an on-the-job accident in their working life (40 years).

Figure 1 **Fatal Accident Rates for Canadian Industries (1975-1980)***



*1980 statistics are preliminary.

Figure 2

Fatal Accident Rates for Ontario WCB Schedule 1 Industries (1977-1980)

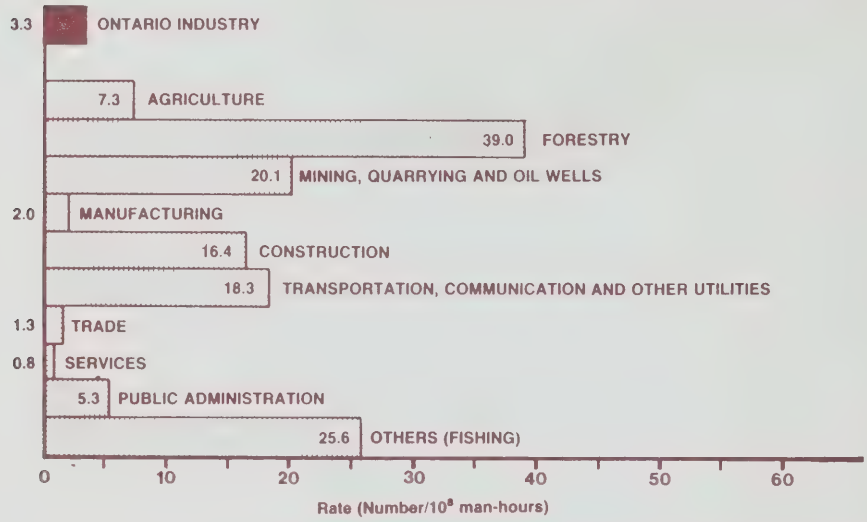
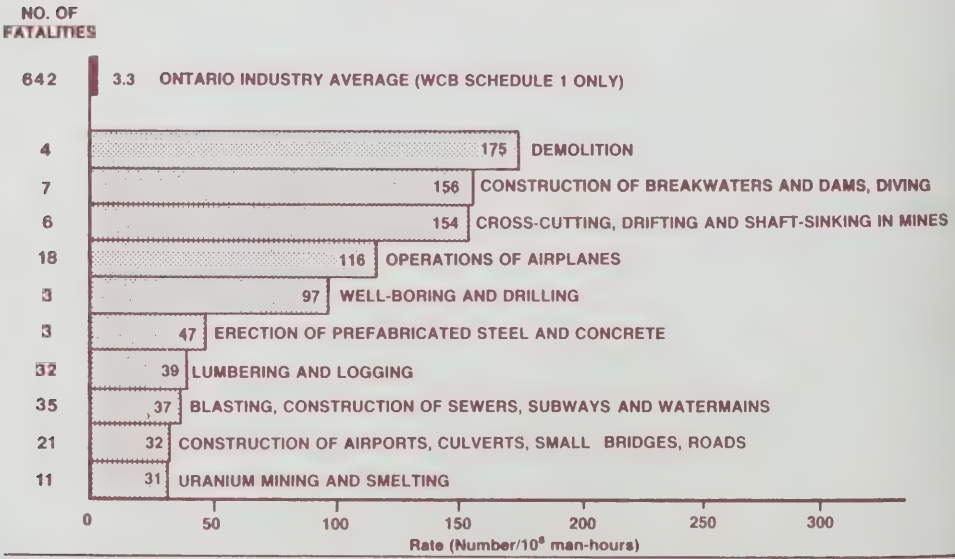


Figure 3

Fatal Accident Rates for The 10 Schedule 1 Rate Groups Having The Highest Accident Rates* in Ontario (1977-1980)


NO. OF FATALITIES
642 3.3 ONTARIO INDUSTRY AVERAGE (WCB SCHEDULE 1 ONLY)
4 175 DEMOLITION
7 156 CONSTRUCTION OF BREAKWATERS AND DAMS, DIVING
6 154 CROSS-CUTTING, DRIFTING AND SHAFT-SINKING IN MINES
18 116 OPERATIONS OF AIRPLANES
3 97 WELL-BORING AND DRILLING
3 47 ERECTION OF PREFABRICATED STEEL AND CONCRETE
32 39 LUMBERING AND LOGGING
35 37 BLASTING, CONSTRUCTION OF SEWERS, SUBWAYS AND WATERMAINS
21 32 CONSTRUCTION OF AIRPORTS, CULVERTS, SMALL BRIDGES, ROADS
11 31 URANIUM MINING AND SMELTING
0
50
100
150
200
250
300
Rate (Number/10⁸ man-hours)

*3 or more fatalities

Figure 4

Fatal Accident Rates for Work Classifications in Ontario Construction (1976-1981)

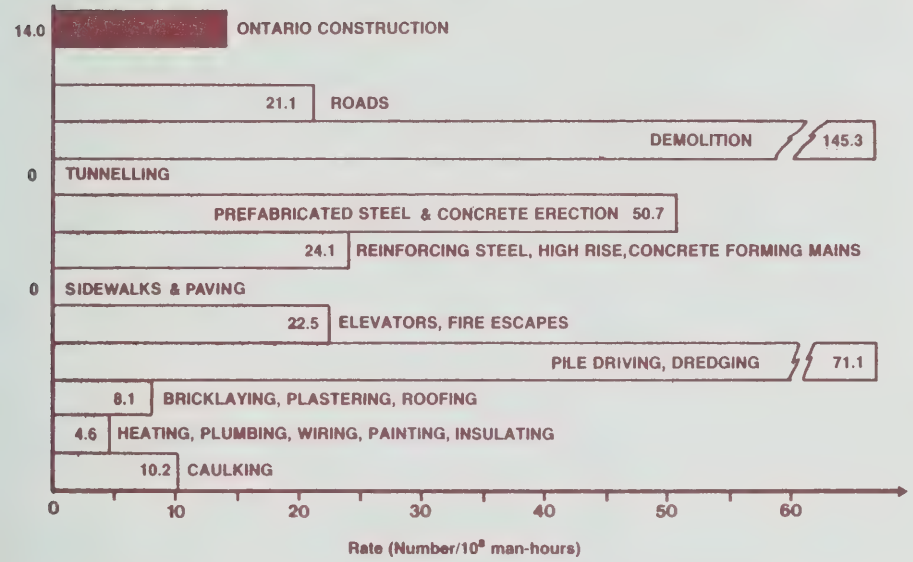


Figure 5

Fatal Accident Rates for the Ontario Forest Industries (1972-1980)

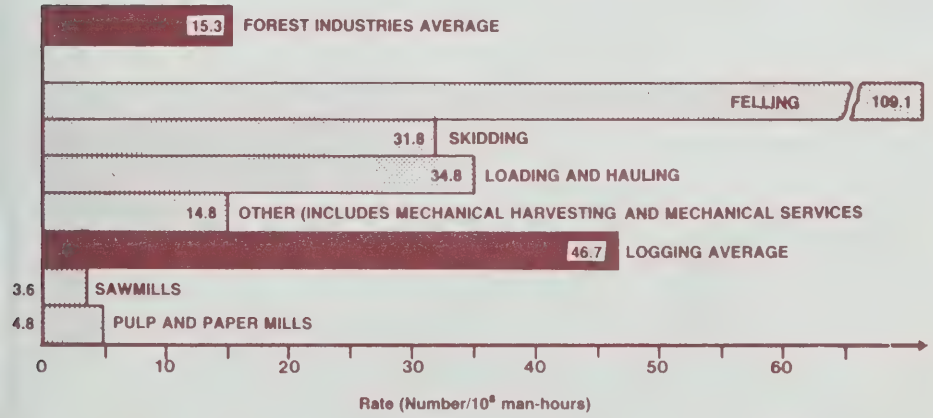
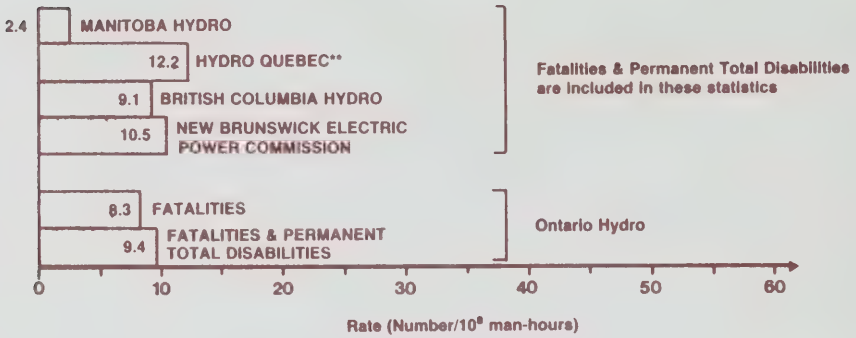


Figure 6

Fatal Accident Rates for Canadian Utilities (1972-1981)



**Hydro Quebec statistics were not available for 1976 and 1977.

Figure 7

Fatal Accident Rates of Major Work Groups in Ontario Hydro (1972-81)

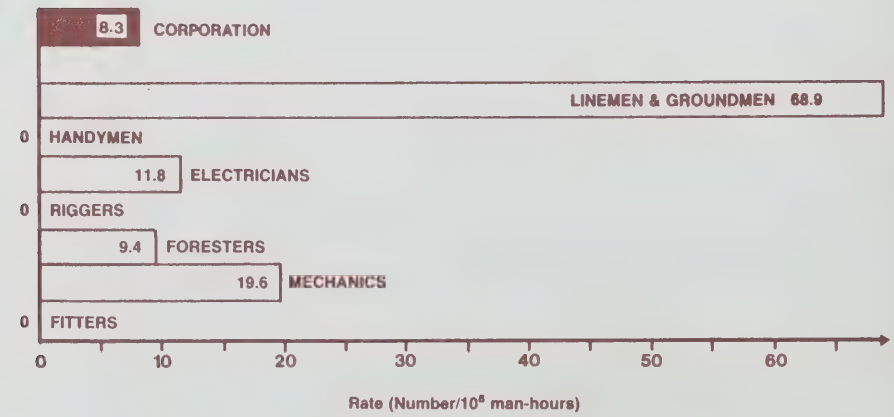


Figure 8

Fatal Accident Rates of Divisions of Ontario Hydro (1972-81)

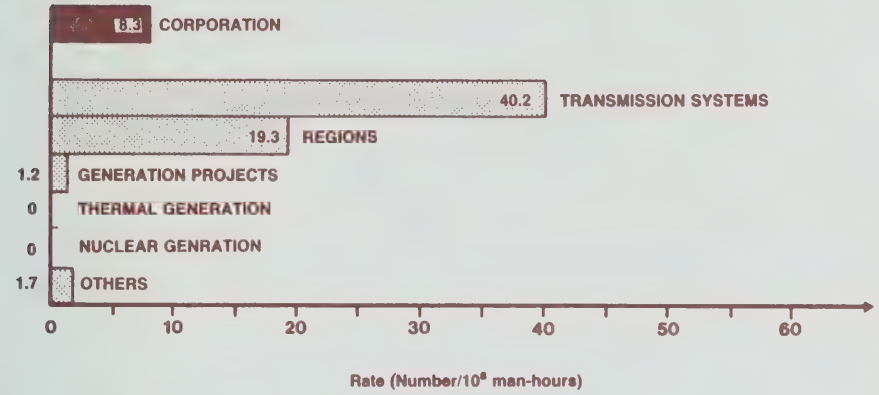
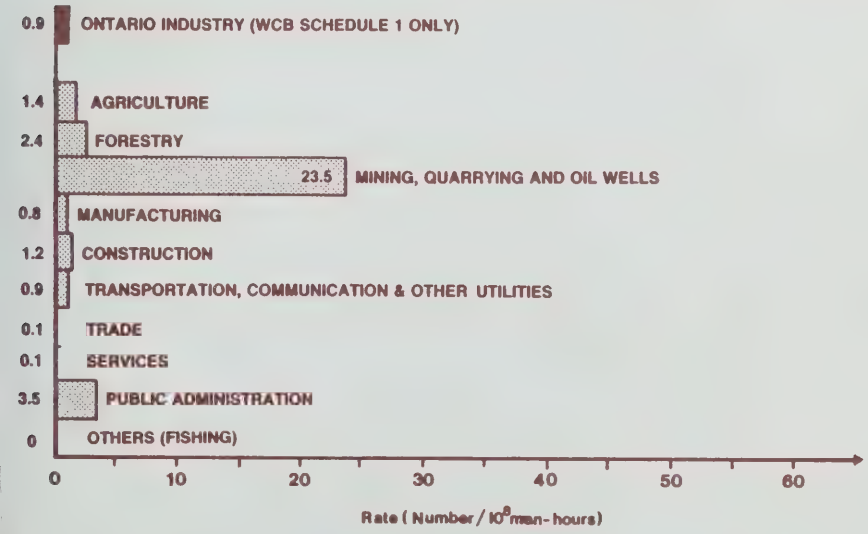


Figure 9

Fatal Disease Rates for Ontario WCB Schedule/Industries (1977-1980)



The data for our own company, Ontario Hydro, is interesting and could be considered as representative of many industries. The average corporate fatal accident rate is between eight and nine fatalities per 10^8 man-hours worked based on a 10-year period. There is, however, a wide variation from this average across the corporation. The results are shown by occupation and by division in Figures 7 and 8. It is fairly clear, on the basis of fatal accident experience, which groups in Ontario Hydro require priority attention.

Occupational Disease

Fatalities from occupational accidents are readily identified and fatal accident rates estimated. As was previously discussed, the identification and relation of fatalities from occupational diseases to toxic agent exposures is not as simple. Traditionally, epidemiological studies have been employed to establish standardized mortality ratios. Such studies have shown associations between lung cancer and mesothelioma and asbestos exposure; nickel exposure has been related to increased incidence of respiratory and nasal cancer; and an increase in leukemia deaths has been associated with exposure of a work force to benzene.

Although epidemiological studies are useful, they require strict experimental control and extreme care in ascribing a causal relationship from a correlation. For example, a study of North American death rates could well show a correlation between the monthly death rate due to drowning and the consumption of ice cream. It would be foolish to ascribe the drowning to the ice cream consumption. Generally, a single epidemiological study requires a number of confirmatory studies before a conclusion is drawn on a causal factor. An example is smoking where the initial study implicating smoking has been confirmed by a number of independent studies, and smoking is now accepted as being causally related to an increased incidence of various cancers.

Acknowledging that extreme care must be taken when drawing conclusions from epidemiological studies, it is nevertheless interesting to look at the values of standardized mortality ratios that have been found to be related to occupation.

In terms of linking disease to occupation, the best available data are for cancer. Bridbord *et al*[4] have listed a number of occupational groups that have been shown to be at increased risk of cancer at specific sites. Some of these occupations are listed in Table 1 without identification of a specific etiologic agent.

Table 1 **Occupations in Which Excess Cancer Incidence Has Been Reported**[11]

Occupational Group	Cancer Site(s)	Standardized Mortality Ratio (%)
Chemists	Pancreas	164
	Lymphomas	179
Textile Workers	Mouth and Pharynx	177
Metal Miners	Lung	300
Cadmium Production Workers	Lung	235
	Prostate	348
Tire Building	Bladder	188
	Brain	190
Furniture Workers	Nasal Cavity and Sinuses	400-500

Wider-ranging studies linking occupation with overall mortality rate and mortality rates for diseases other than cancer are quite sparse. One of the more recent studies is one by the Society of Actuaries[5] on the experiences of 17 life insurance companies. The data are from both the United States and Canada, and span a 10-year period from 1955 to 1964. Table 2 is an extract of these data

Table 2 **Standardized Mortality Ratios (SMR) for Various Occupations Having a Ratio Greater Than 175 for Malignancies**[5]

Occupation	SMR (%)	
	Cancers	All Causes
Structural Iron: Supervisors and Workers	262	210
Laundry Workers	255	140
Railroads: Firemen	227	168
Garbageman (Public)	217	179
Truck Drivers	213	193
Underground Mining: Machinists and Mechanics	211	203
Keepers and Managers (Liquor Principal Business)	208	164
Liquor: Retail Dealers	190	167
Underground Mining: Non-Metal, Non-Coal Miners	184	259
Metals: Buffers and Polishers, Grinders	179	131
Labourers: Trade	178	138
Liquor: Salesmen (Outside)	176	164

and gives the SMRs for various occupations having a value greater than 175 for malignancies. Most of the occupations having a high SMR for malignancies also have a high SMR for death from all causes.

From these data some remarkably high SMRs are see for causes of death other than cancer. Some of these are listed in Table 3. The difficulty of proving that occupation is the cause of death is illustrated by liquor dealers

Table 3 **Standardized Mortality Ratios (SMR) for Various Occupations From Causes Other Than Cancer[5]**

Occupation	Cause	SMR (%)
Underground Mining: Coal Miners	Pneumonia, Influenza and Tuberculosis	1,111
Liquor: Retail Dealers	Digestive (Other Than Cirrhosis of Liver)	1,094
Liquor: Retail Dealers	Cirrhosis of Liver	1,053
Bartenders	Cirrhosis of Liver	1,037
Lumbermen: All Areas	Non-motor Vehicle Accident and Homicide	1,009

and bartenders dying from cirrhosis of the liver: It is not clear whether the work environment produces the condition or whether perhaps those with the condition are attracted to the occupation.

Howe and Lindsay[6] have derived SMRs for various Canadian occupations by linking death records with a register of occupational history for a 10 per cent sample of the Canadian labour force maintained by Statistics Canada. The SMRs were calculated with respect to the whole 10 per cent sample to eliminate the 'healthy worker effect'. The authors caution that the paper is intended primarily to highlight the methodology and tha the results are not definitive because of various confounding factors and because the large number of comparisons made will produce some high values by chance. SMRs for lung cancer and various other cancers are shown in Tables 4 and 5. These tables show the wide range of SMRs that have been observed for different occupations.

A significant problem with these studies is that the confounding effects of socio-economic factors and smoking have not been allowed for. These effects are of major importance as Fox and Adelstein[7] showed in their analysis of occupational mortality data for the United Kingdom.[8] They found considerable variation in the overall

Table 4 **Standardized Mortality Ratios (SMR) for Various Canadian Occupations for Lung Cancer Deaths (Males Only)[6]**

Occupation	SMR (%)
Bartenders	213
Messengers	182
Bricklayers, Stonemasons, Tilesetters	176
Fitters and Assemblers—Metal	170
Plumbers and Pipefitters	168
Inspectors—Metal	162

Table 5 **Standardized Mortality Ratios (SMR) for Various Canadian Occupations for Various Cancer Sites (Males Only)[6]**

Occupation	Cause of Death	SMR (%)*
Waiters	Buccal Cavity and Pharynx Except Lip	718
Bartenders	Buccal Cavity and Pharynx Except Lip	635
Service Station Attendants	Bladder Plus Other Urinary Organs	529
Sales Clerks	Prostate	258
Messengers	All Cancers	182
Bartenders	All Cancers	175

*Significant at the 0·1% confidence level.

age-standardized mortality rates between 25 broad occupational orders. Considerable variation in SMR and life expectancy was also found with social class, as shown in Table 6.

Table 6 **Differences in Standardized Mortality Ratio (SMR) and Life Expectancy for British Social Classes[7]**

Social Class		SMR (%)	Increase in Life Expectancy (days)
I	Professional, Managerial	77	580
II	Intermediate	81	480
III N	Non-manual Skilled	99	25
III M	Manual Skilled	106	−150
IV	Partly Skilled	114	−350
V	Unskilled	137	−920

When the SMRs for the 25 occupational groups were standardized for social class, the total variation between occupational orders was reduced by 82 per cent. This leaves some 18 per cent to be explained by occupational factors and by confounding factors, such as smoking habits, which are not completely corrected for by the social class standardization. Epidemiological studies which do not take socio-economic factors into account may considerably overestimate the SMRs attributed to occupational factors.

Cohen[9] has extensively reviewed the variation in risks and life expectancies for different occupations. In his analysis of U.K. occupational mortality data, he made a correction for social class. Table 7, taken from his work, lists SMRs for overall mortality and the increase in life

Table 7 **Standardized Mortality Ratios (SMR) for British Occupational Groups with Low SMRs[9]**

Occupation	SMR (%) Raw	SMR (%) Soc. Class	Increase in Life Expectancy ILE (days)
Engineering Foremen	47	45	1,380
Paper Products Makers	50	47	1,330
Electrical Engineers	42	56	1,110
Builders Labour	80	57	1,080
Electrical Fitters	67	64	900
University Teachers	49	64	900
Managers—Building	54	66	850
Press Workers, Stampers	78	69	780
Local Senior Officers	57	70	750
Postmen, Mail Sorters	81	72	700
Packers, Labellers	83	73	690
Engineering Trades Labour	101	75	630

expectancy (ILE) for occupations with low SMRs. Conversely, Table 8 lists SMRs for overall mortality and loss of life expectancy (LLE) for occupations with high SMRs. It is noteworthy that the highest LLE, 2,900 days for ships' officers, can be equated to a fatal accident rate of over 300 fatalities per 10^8 man-hours. Furthermore, there is a difference of 10 years in life expectancy between the safest occupations shown in Table 7 and the riskiest in Table 8.

Table 8 **Standardized Mortality Ratios (SMR) for British Occupational Groups with High SMRs[9]**

Occupation	SMR(%) Raw	SMR(%) Soc. Class	Loss of Life Expectancy LLE (days)
Ships' Officers	175	216	2,900
Ship or Barge Workers	233	205	2,600
Electronic Engineers	145	196	2,400
Publicans, Innkeepers	155	190	2,250
Garage Owners	140	173	1,830
Steel Erectors, Riggers	164	158	1,450
Actors, Musicians	124	154	1,350
Fatal Accident Rate of 100 Fatalities per 10^8 Man-hours			925*

*Estimated from Table 3 of Cohen[9]

Finally, to return to Ontario, Figure 9 shows fatal disease rates for broad groupings of Ontario industries. It is apparent that mining is particularly hazardous in terms of occupational disease, presumably because of the large exposures to dust and, in the case of uranium mining, to radon. During the four-year period shown, 54 per cent of the mining fatalities were ascribed to occupational diseases.

Risk to Ontario Hydro Nuclear Workers

From the data given in Figure 8, it is clear that the fatal accident risk in nuclear station work is low: There have been no fatal accidents in over 80 million man-hours worked.

In 1973, a retrospective/prospective epidemiological study of Ontario Hydro workers was begun. The study is a cohort study retrospective to 1970 and, of course, prospective since 1973. The standard mortality ratio for various work groups have been determined for various causes of death in the work force since 1970. The results are given in Table 9.[10] The results must be viewed with caution for the following reasons:

1. The healthy worker effect is undoubtedly present.
2. The time which has elapsed since the bulk of the work group exposure is less than 13 years.
3. The statistical significance is poor.

With these caveats in mind, the results in Table 9 do, nevertheless, give some reason for cautious optimism

Table 9	Ontario Hydro Standardized Mortality Ratio*[10]			
	Nuclear	Thermal	Other	Total
All Causes	60	69	81	80
Neoplasma (Cancers)	(58)	97	88	87
Circulation (Heart, Stroke)	(49)	67	87	86
Accidents (Occupational and Non-Occupational)	92	54	72	73
All Other Causes	(8)	59	57	56

*Observed deaths expressed as a percentage of predicted deaths (based on cumulative experience 1970-1981).

Parentheses indicate results based on less than 10 observed deaths.

that, at the current exposure levels, the risk of fatal diseases in nuclear station work is low. Certainly, the SMRs for nuclear station workers compare favourably with those for other occupations as given in Tables 1 through 5 and Table 8.

It is also interesting to compare the SMRs of the various occupations given in Tables 1 through 8 with the SMRs of the Japanese bomb survivors of Hiroshima and Nagasaki (Table 10).[11] This information is one of the

Table 10	Cancer Mortality in Hiroshima and Nagasaki (1950-1974)[11]						
	Mortality Ratios* for Various Dose Groups						
Cause of Death	1-9 rads	10-49 rads	50-99 rads	100-199 rads	200-299 rads	300-399 rads	400+ rads
Leukemia	62	76	96	281	577	1,000	1,250
All Other Cancers	97	102	103	114	139	105	158

*Observed deaths expressed as a percentage of expected deaths based on Japanese National Statistics.

principal studies on which risk estimates for exposure to ionizing radiation have been made by various authorities such as the International Commission on Radiological Protection (ICRP), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)[12] and the committee established by the U.S. National Academy of Sciences to study the Biological Effects of Ionizing Radiation (BEIR).[13] Except for the >400 rem dose interval, the SMRs are surprisingly low.

With an accumulated population dose for Ontario Hydro's nuclear station workers of 28,000 man-rem, the Ontario Hydro mortality study is not statistically powerful enough to estimate the radiation risk to these workers or to verify the risk per rem value of other studies (i.e. one or two additional cancers would be difficult to establish statistically). On the other hand, it is highly unlikely that a risk value which was 10 times higher would not have begun to influence the fatalities due to cancer in the work force.

Another way of considering the risk faced by nuclear station workers is to use an appropriate risk per rem value and calculate an equivalent fatal accident rate.

The first column of Table 11 gives the average annual lifetime doses of work groups in Ontario Hydro's Nuclear Generation Division. The ICRP recommended

Table 11 **Equivalent Fatal Accident Rate of Nuclear Generation Division Work Groups**

	Equivalent Fatal Accident Rate**		
Work Group	**Annual Lifetime* Average Radiation Dose (rem/year)**	**Unadjusted Number/10^8 Man-hours)**	**Adjusted *** (number/10^8 Man-hours)**
All Nuclear Employees (5,901 Employees)	0·43	2·2	0·9
Mechanical Maintainers (709 Employees)	0·99	5·0	2·0
Operators (974 Employees)	0·80	4·0	1·6
Control Maintainers (608 Employees)	0·49	2·4	1·0
Service Maintainers (727 Employees)	0·19	1·0	0·4

*Ontario Hydro's computer based dose record system as of the end of 1981.
**Due to exposure to ionizing radiation assuming a risk per rem value of 10^{-4}.
***Adjusted to account for reduced years of life lost in the case of malignancies.

value of 10^{-4} fatalities per rem[14] has been applied to this to give an equivalent fatal accident rate. In the unadjusted estimation, no allowance has been made for the fact that for an occupational fatality due to trauma, the loss of life is from the time of the accident, but in the case of a fatality due to a malignancy resulting from occupational exposure to a toxic agent such as radiation, the years of life lost are much less for two reasons; the radiation exposure is extended in time and the latency

period may vary from a few years in the case of leukemias to tens of years for solid tumours.

In ICRP-27,[3] it was estimated that the average period of life lost per fatal malignancy was 10 to 15 years, as compared to the average loss of about 30 years of life in the case of an occupational fatality due to trauma. Based on this, a modifying factor can be derived and used to adjust the equivalent fatal accident risk of nuclear workers, thereby taking into account the fact that fewer years of life are lost due to a malignancy. The third column of Table 11 has been constructed by applying this modifying factor.

The Nuclear Generation Division work group with the highest average radiation exposure is mechanical maintenance. This group has an estimated equivalent fatal accident rate of 2·0 fatalities per 10^8 man-hours. Since there have been no on-the-job fatalities to NGD workers in over 80 million man-hours, the total fatal accident rate for this work group compares favourably with other industries, even though no allowance has been made for the possible effects of toxic agents associated with other industries.

Discussion and Conclusions

The data presented here on occupational fatal accidents show a wide variation in the fatal accident rate from industry to industry, with some industries in Ontario having a rate 10 times greater than the average for the province. Within a given industry, the variation in rate from the average is almost the same size, which means that in specific occupations, fatal accident rates may be 50 times the provincial average. Industries and occupations with such high rates require industry and regulatory agency priority and attention, although the rate is obviously not the only consideration. The total number of fatalities occurring must also be taken into account.

There is a surprising variation in SMRs over various occupations and industries. The variation may not be primarily due to occupational factors, as is illustrated by the effect of social class on the U.K. data. Confounding factors such as this and smoking make it necessary for extreme care to be taken in drawing conclusions from epidemiological studies. Nevertheless, such studies have played an important role in the past in identifying harmful agents in various occupations, and will continue to do so.

The importance of the work of Cohen in attempting to establish a common base (loss of life expectancy) in comparing fatal accident rates with standardized mortality ratios cannot be overemphasized. This type of infor-

mation, along with knowledge of the costs associated with the reduction in the risks, enables rational decisions to be made in the allocation of limited resources.

Here, in Canada, this approach has been advocated by Siddall.[15] Although perceived risks must be acknowledged, professionals in health and safety must rely on rational knowledge of risks and the factors associated with their reduction.

Résumé

Trois mesures des risque encourus par les travailleurs dans l'industrie font l'object de discussion; il s'agit du taux d'accidents mortels, du taux normalisé de mortalité et de la réduction de l'espérance de vie. Les taux d'accidents mortels varient largement selon les industries et les emplois au Canada et en Ontario et les occupations les plus dangereuses sont près de 50 fois plus risquées que la moyenne. Les taux normalisés de mortalité varient aussi largement selon les maladies et les emplois. Certaines différences sont dues aux différences de classes sociales, mais quand on en tient compte, une différence de 10 années dans l'espérance de vie persiste en Angleterre entre les emplois les moins dangereux et ceux qui le sont le plus. L'accumulation de renseignements sur les différences entre les risques dans l'emploi et le coût associé à la réduction du risque permet d'arriver à des décisions rationelles pour l'affectation des ressources disponibles.

Acknowledgements

The authors would like to thank Mrs. D. Stainback for her assistance in compiling much of the fatal accident rate data for Figures 1 through 8.

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Work Practices to Reduce Heat Strain

Summary

Body temperature must be maintained within narrow limits to prevent a deterioration in function. Health, and even life, can become jeopardized by a rise in core or deep body temperature. Maintenance of body temperature is dependent upon a balance where heat loss equals body heat production plus heat that is gained from the environment. The work practices described in this paper affect one or more of these variables in the heat balance relationship.

The benefits of individual characteristics such as physical fitness and acclimatization for heat stress are discussed. Factors that are important for the selection of work and rest scheduling are also outlined.

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Introduction

Regulation of deep body temperature is important to prevent impairment of optimal physical and mental work capacity. Core temperature is normally near 37°C and should not exceed 38°C at work to prevent any impairment in function from developing. An individual can only tolerate an internal temperature exceeding 41°C for a brief period of time before serious effects occur. Hyperpyrexia usually occurs at 40·5°C with a breakdown of the thermoregulatory process. If the temperature of the body is to remain constant, heat loss must equal heat production and heat gain from the environment.

The human body continuously produces heat from metabolic activity, which helps maintain core temperature close to 37°C. When a person engages in physical work the muscular activity also produces heat since only a portion of the energy released in the metabolic breakdown of foodstuffs is transferred into external work. The harder a person works the more heat they produce and must dissipate. This factor exerts a strong influence on the ability to perform work in a hot environment.

Characteristics of the environment such as temperature, humidity and air velocity influence how easily heat is transferred away from the body. If the skin is much warmer than the air, convective and radiative exchanges combine with evaporation to dissipate body heat. When environmental temperature approaches skin temperature then only evaporation can reduce body heat. If environmental temperature exceeds skin temperature then the body gains heat and all the heat loss must be accomplished by evaporative mechanisms. Sources of radiant heat can increase the heat gain from the environment. High levels of humidity reduce the ability of the body to cool itself by evaporation.

The objective of this paper is to describe some work practice considerations that can reduce the physiologic strain on the worker. Awareness of such techniques by employers and health and safety committees can assist in

improving work tasks performed in hot environments. Companies that have lengthy experience with heat stress will likely have evolved their production practices so that they incorporate some or all of these suggestions. For example, the need for acclimatization of workers to reduce heat strain has long been recognized by many of these employers. This will not likely be the case for new employers or those with infrequent heat stress periods. It is for these situations that the material in this paper may be of most value.

Response to Heat Stress

Heat stress results in the occurrence of physiological changes within the body to prevent a rise in body core temperature. Heart rate increases and the small blood vessels in the skin dilate. Blood is directed away from the splanchnic and renal regions as well as non-working muscles. If not enough heat can be released by this redistribution of blood then heat sensors activate the sweat glands to release fluid. This sweating mechanism is only effective in increasing heat loss if the perspiration is removed from the skin by evaporation. In high humidity environments evaporation from the skin surface is reduced and large quantities of body fluids can be lost with very little cooling of the body. Under these conditions the worker's ability to do the job is affected.

The degree to which a person responds to a specific heat stress situation is influenced by characteristics of that individual. Physical fitness, state of heat acclimatization (adaptation to heat) and body size are examples of factors that influence the physiologic strain that the person experiences. For this reason workers need to be selected carefully with full consideration of the above factors, and then matched against the task to be performed. Excessive working exposure to a hot environment can bring on a variety of physical disorders ranging in severity from discomfort to death. A description of these disorders can be found in the Appendix to this paper.

Approaches to Reduce Heat Stress

There are essentially two approaches that can be used to reduce heat stress and thus decrease the extent of strain experienced by workers. An engineering approach usually attempts to modify the environmental factors that contribute to heat stress. This modification includes such things as the use of air cooling equipment, humidity reduction, increasing air movement and shielding radia-

tive heat sources. These techniques can be very effective in some work situations, but are not practical or possible in others. An alternative approach is to use work practice techniques to reduce the strain. This approach influences how the work is done and thereby decreases the body heat generated from metabolism and/or reduces the buildup of body heat. These work practice techniques are practical and effective in reducing heat strain when working in elevated temperature environments.

Work Practice Techniques

Drinking-water

Sweating is the primary mechanism for releasing body heat under heat stress conditions and it is imperative that workers be able to replace the lost body fluids during the work period. Workers exposed to intense heat may lose as much as six to seven litres of sweat in the course of the working day.[1] Drinking-water must be located close to workers in all high heat situations. Workers should be encouraged to drink water because the sensation of thirst is an inadequate drive to stimulate a large intake of fluids in a short period of time.[2] The water should be cool (10-15°C), and cups should be supplied since people tend to consume greater volumes when drinking from a cup than when drinking from a fountain. Workers with continuous exposure to high heat areas should make a habit of drinking fluids every 15 to 20 minutes, and more than is necessary to satisfy thirst. The necessity of adding salt to the drinking-water is controversial. There are some indications that the use of salt tablets or salted drinking fluids may interfere with the body's natural adaptive response, which is to reduce the amount of salt in sweat.[3] Since excessive salt intake can cause nausea, vomiting and diarrhea, and since the occurrence of cramps is readily reversible with salt intake, it is suggested that salted water not be used until an individual experiences symptoms of heat cramps. This is the same position that the military recommends.[3] One other potential problem with salted water is the consumption of it by individuals who are on a restricted salt diet for medical reasons.[4]

Acclimatization

Acclimatization is the process of adapting to one's environment. In the case of heat stress, if a person is regularly exposed to a hot environment their body will undergo

adjustments so that the physiologic strain is reduced. The improvement in heat tolerance, seen after a few days' exposure, is associated with increased sweat production and a lowered skin and body temperature. The onset of sweating occurs at lower skin and core temperatures resulting in less of an accumulated heat load. Sweat production can increase by as much as 100 per cent with acclimatization.[2] This increased sweat production provides the capability for a more effective cooling of the skin through evaporative heat loss. The lowered skin temperature provides for a better cooling of the blood flowing through the skin. Thus, the amount of blood flow to the skin is reduced, which, in turn, decreases the strain on the cardiovascular system. Heart rate for a given work load is reduced and central circulation is improved following acclimatization as a result of an improved heart rate to stroke volume ratio.

Large amounts of sweat loss can result in salt depletion since sweat contains varying concentrations of different salts. The process of acclimatization affects the salt concentration of sweat in that the amount of salt per volume of sweat decreases as acclimatization improves.[1] For this reason, and because of the fact that the average Canadian diet contains an excess of salt, supplementation of salt may only be necessary during the first few days of heat exposure.

Numerous acclimatization schedules exist either to reduce the time required for acclimatization or to ensure that full acclimatization has been attained. Most of the benefits occur in the first three or four days, and almost complete adaptation develops in seven to 11 days. If muscular work is involved in the exposure to heat, physical work should be included in the acclimatization period. One schedule of acclimatization calls for the person to work at a 50 per cent anticipated total work load/time exposure on the first day, followed by 10 per cent daily increments to reach 100 per cent exposure on the sixth day.[5] Simultaneous exposure to both heat and exercise is recommended for optimal heat acclimatization.[1]

The loss of acclimatization is often a concern when individuals are absent from heat exposures because of holidays or sickness. Although effects of heat acclimatization persist for several weeks, some impairment in heat tolerance may be detected for a few days following return to work.[1] Since the adaptive response is not lost quickly, Goldman suggests that a formal schedule for reacclimati-

zation is not as important as for initial acclimatization.[3] The situation where workers are returning after an illness presents additional complications. In this circumstance it is important that the plant or personal physician is aware of how the return to work in the heat interacts with the specific illness.

Training and Education

It is very important that employees and their supervisors are able to recognize the initial signs of heat strain in order to prevent the deterioration of health. (See the Appendix for symptoms of heat stress disorders.) The workers should be made aware of the need for fluid consumption and should attempt to monitor their fluid balance by weighing themselves before and after a work shift. It is also very important that supervisors are aware of the environmental factors and the characteristics of individuals that contribute to heat strain. This information will allow them to anticipate circumstances that may make workers more vulnerable. It should also be incorporated into decisions of worker assignment to specific work tasks. New employees, people returning to work following sickness or holidays, and repairmen who do not normally work in hot areas are more vulnerable than regularly exposed individuals. Workers with a fever should be advised not to work in a hot environment. The first hot spell is often more stressful, as are periods of high humidity. When ambient temperatures are greater than skin temperatures small individuals are at a disadvantage because of their high surface area to body mass ratio.[6] The importance of how strenuous the task is as a contributor to heat balance should be outlined. The need for rest pauses and the importance of taking them in a cool location is vital information for workers and supervisors to be aware of.

Fitness

Physical fitness also affects how well an individual can tolerate heat stress. Physical training appears to increase sweat gland secretion. The increased metabolic rate during training requires a high degree of thermoregulation and apparently this demand induces an increased sensitivity of the sweat glands to the central sweating drive.[1] Physical training also improves the cir-

culatory capability to supply blood to the peripheral circulation while still meeting the blood flow requirements of the working muscles.[7] The maximum amount of blood that the heart can pump per minute increases with physical training, and thus there is a greater reserve capacity to cope with the changes induced by exposure to heat.

Clothing

The amount and type of clothing can dramatically affect the heat strain experienced by a worker. The selection of work clothing should consider the environmental factors that affect heat stress (e.g. humidity, radiant heat sources and air movement). In a moist hot climate where environmental temperature is less than skin temperature it is beneficial to wear as little clothing as possible provided that sources of radiant heat are not present. When sources of radiant heat are present or environmental temperature is high then clothing may provide protection for the worker. Ideally, the clothing should permit free circulation of air. Cotton fabrics, which have a high vapour permeability and high thermal conductivity are beneficial in hot-wet environments. They absorb sweat very efficiently and permit the rapid flow of heat from the body. Woollen fabrics have a low thermal conductivity but a high vapour permeability and would provide protection from radiant heat while still allowing perspiration to evaporate.

Specialized protective clothing is required if the work environment is extremely hot. This clothing either insulates the wearer from the heat, reflects radiant heat or contains a cooling source to prevent injury to the worker. While these are essentially engineering approaches to reduce heat stress, the work practices outlined in this paper have impact on the use of this clothing. The excess weight and restrictions to freedom of movement both contribute to earlier onset of fatigue, and work-rest schedules should plan for this. These suits also develop a microclimate within them, which could be unfavourable to the worker. This also can be a major problem when impermeable materials are used to protect against toxic and carcinogenic agents. Work practice techniques should also be used in these situations since heat stress can develop within the suit even when ambient temperatures are comfortable.

Scheduling

Though acclimatization and fitness improvement are very useful ways to reduce heat strain, there is a limit to the role that they can play in a total program to manage heat stress. Work scheduling provides powerful complimentary assistance for heat strain reduction.

One of the most effective uses of scheduling to reduce heat stress is to perform strenuous tasks during the coolest times of the day. This likely will not be possible for all tasks, but things such as repair of machines or heavy clean-up may be done during cooler periods. In some cases, work environments are just too hot to allow continuous exposure of the worker. When this is the case, a schedule of intermittent work with sufficient rest periods is necessary. This can prevent the accumulation of heat to dangerous levels, and also allows the release of heat before the person returns to the task. While the person is resting there is little metabolic heat generated and this allows the amount of heat released to exceed heat produced.

The American Conference of Governmental Industrial Hygienists has published threshold limit values for intermittent heat exposures for different metabolic loads.[8] Time-weighted exposure limits have also been calculated. In general, the greater the heat stress the longer are the rest periods that are required. However, the timing of the breaks is important, as is the total length of rest periods during the day. Brouha describes a situation where one-hour work, one-hour rest intervals presented more of a physiologic strain than did half-hour work-rest periods.[9] With the one-hour changes, workers were experiencing higher heart rates in the afternoon. When the half-hour rotations were used, the cardiovascular reaction to the work task in the afternoon was the same as in the morning. Brouha explains that the one-hour work periods produced too great a heat load to allow recovery in one hour, while the heat load of a half-hour work period could be relieved with a half-hour rest. This schedule prevented the accumulation of body heat later into the work shift.[9] Brouha concludes that in a warm environment, the principle of alternating short periods of work and rest should be applied whenever possible.[9]

The rest place environment is very important in determining how effective the rest pause is in reducing the

physiologic heat load. Air conditioned rest areas influence whether a rest pause is sufficient for all physiologic parameters to return to equilibrium before returning to the task. Maintaining a low humidity within the rest environment assists in recovery since sweat evaporation is enhanced, and also the clothing will dry. It is important that rest breaks be long enough to allow full recovery; if restoration is not complete, the deficit will accumulate and performance later on in the shift will be affected. Laboratory experiments have demonstrated the favourable effect of resting in a cool environment.[9,10] When rest periods were taken in a cool environment, the heart rate remained at a lower level during the whole experiment and barely increased as more work cycles were performed. On the other hand, when the heat exposure was continuous, the cardiac stress increased progressively and the heart rate rose as the work task was continued.

Establishing adequate rest periods is not an easy task since so many factors affect their recuperative value. Close collaboration of a physiologist and an industrial engineer is required so that changes in rate of work and production can be evaluated together with changes in physiological reactions.

Another aspect of scheduling that will influence heat strain under certain conditions is work in different temperature environments. In this circumstance there are no clear divisions between work and rest, but, rather, the job involves rotation between different environments. How the rotation is arranged can affect resistance to heat strain. There appears to be an advantage in performing the greater strain tasks first and then proceeding to the less stressful task rather than vice versa.[9] For example, equal work loads in different environments resulted in a body temperature increase of 0·6°F (0·3°C) when rotation was from cool to warm, but an increase of only 0·2°F (0·1°C) when rotation was from warm to cool. Maximum heart rates were the same for both rotations, but cardiac debt was greatest in the cool to warm sequencing. One, two and three-minute recovery heart rates were higher for the cool to warm sequencing. When the work load in the two environments was increased, the rotation effects became more pronounced.

Brouha feels that the difference between these reactions can be explained on the basis of heat dissipation. When the person works first in the heat, he is able to 'pay back' part of the heat debt while he continues working in a cooler environment. This is not possible when the

sequence is reversed. Since there is a greater accumulated heat debt, the recovery processes (thermal and cardiovascular) take place more slowly.[9]

These findings suggest that in industrial operations work, cycles should be organized, if possible, according to the schedule: warm work to cooler work to rest period. Under these conditions and for the same amount of work, the duration of the rest periods could be reduced without increasing the physiological cost of the cycle.

The same principle would be of benefit when tasks of different work intensity must be done in the same environment. In this case, if the higher intensity task is done first then some recovery can occur during the time spent on the less strenuous task.

Work Process Modification

Since heat stress results from a combination of environmental factors and metabolic heat production, reducing the metabolic generation of heat will reduce the heat strain that is experienced. Reducing work pace, increasing the number of workers to do a task or changing the mode of work can all reduce the metabolic heat production and/or cardiovascular strain.

The reduction of work pace when conditions are hot will likely occur naturally in most situations. Supervisors should be sensitive to the need to slow down under hot conditions. Problem situations can develop when motivation is high (e.g. piece work) or if the work is not self-paced (assembly line production). When these situations exist, it should be the supervisor's responsibility to modify the work pace to within safe levels.

Adding more people to a work crew can be effective in reducing the demand on any one individual by either increasing the length of rest periods or decreasing the work intensity required of each individual. In studying three and four-man crews, Brouha found that physiological strain was lower with the four-man crews, but also found that productivity per worker was higher in this group. This was attributed to the fact that less time for rest was needed per man. The final result of using the four-man crew versus the three-man crew was that the increased output was sufficient to cover more than the cost of the additional worker. The greater the physiological stress, the greater the improvement achieved by adding an extra worker.[9]

Many industrial operations can be made easier if the position of the body (static contraction), the nature of the motion (dynamic contraction) and the speed of motion (rate of contraction) are so arranged that the physiological cost of the job is reduced to a minimum.[9] This essentially involves changing how the work is done. One way to accomplish this is to introduce mechanical aids into jobs that involve hard manual labour. An example of such a mechanical aid in material handling would be the two-wheeled hand cart. Rather than having to bend over, pick something up and carry it, the worker now, essentially, has only to push or pull the loaded hand cart. Mechanical aids such as these are either presently available or need to be designed for the specific work task. Work that involves prolonged standing can be additionally stressful in the heat because of the hydrostatic pooling of blood in the legs. Postural changes can also be effective in reducing worker strain. Workers performing a skimming operation to remove impurities from molten metal attained heart rates of 160 beats/min when the tank was at shoulder height, but had heart rates of only 112 beats/min after a platform was built to lower work height. A final example of a simple work change to reduce strain is an example of a worker loading 22-kg bags on a platform. The usual process was to stack the bags seven high to a height of approximately 1·8 metres (6 ft.), but it was found that the energy spent by the worker in loading the upper two courses was too great in relation to loading all five others. The length of time taken for that part of the operation was also greater, so a double economy of time and physiological cost was achieved when the load was limited to five courses of bags.

Work process modification can be very effective in reducing physiologic strain, but unfortunately there are few universal solutions; thus, very often, each work task has to be evaluated on its own requirements. When making work process changes to reduce strain it is important to determine the effects on the workers as well as on such things as output and cost.

Conclusion

Workers must be protected from too great a rise in core temperature when working in a hot environment. The heat stress that the person is exposed to is affected by the work environment and characteristics of the work task. Modification of either of these two factors can reduce

heat strain. Work practices can substantially reduce heat strain within a hot environment. To optimize this reduction the principles for reducing heat strain need to be incorporated into the specific circumstances of each workplace.

Appendix

Excessive working exposure to a hot environment can bring about a variety of health disorders among workers. These disorders and their associated symptoms are outlined below:*

Transient Heat Fatigue
Transient heat fatigue refers to the state of discomfort and psychological strain arising from prolonged heat exposure. Workers unacclimatized to the heat are particularly susceptible, and can suffer, to varying degrees, a decline in task performance, co-ordination, altertness, vigilance, and become irritable and depressed. The severity of transient heat fatigue can be lessened by a period of gradual adjustment to the hot environment.

Heat Rash
Heat rash, also known as prickly heat, is likely to occur in hot and humid environments where sweat is not easily removed from the surface of the skin by evaporation. The sweat ducts are plugged, and sweat glands inflamed, and a rash soon appears. When extensive, or when complicated by infection, prickly heat can be so uncomfortable as to reduce a worker's performance. This condition can be prevented by resting in a cool place at regular intervals and by taking a shower after each workshift.

Fainting
A worker who is not used to hot environments and who stands erect and immobile in the heat may simply black out. With enlarged blood vessels in the skin and in the lower part of the body, blood may pool there rather than return to the heart to be pumped to the brain. Once lying down, the worker should soon recover. By moving around, and thereby preventing blood from pooling, further fainting while standing can be prevented.

*From *Hot Environments,* U.S. Dept. of Health and Human Services, Public Health Service. U.S. Government Printing Office, Publication No. 80-132. Washington, D.C. 10402, 1980.

Heat Cramps

Heat cramps are painful spasms of the working muscles of those who sweat profusely in heat, who drink large quantities of water, but fail to replace their bodies' salt loss. The drinking of water tends to dilute the body's extracellular fluids, while it continues to lose salt. Soon, the low salt in the muscles causes painful cramps. The affected muscles may be part of the arms, legs, or abdomen, but tired muscles (those used in performing the work) are usually the ones most susceptible to cramps. Cramps may occur during or after work hours, and may be relieved by drinking 1 glass of water containing 1/2 teaspoon of salt.

Heat Exhaustion

Heat exhaustion includes several clinical disorders, all of which reveal similar symptoms. The condition is caused by the loss of fluid in sweating, sometimes by the loss of salt and often by both. The worker with heat exhaustion still sweats, but experiences extreme weakness or fatigue, giddiness, nausea, or headache. In more serious cases, the victim may vomit and/or lose consciousness. The skin is clammy and moist, and complexion is pale or flushed, and the body temperature is normal or slightly higher. The unacclimatized, the physically unfit, and the obese are more prone to develop heat exhaustion.

In most cases, treatment is simple: have the victim rest in a cool place and give him or her plenty of lightly salted liquids. Mild cases may result in spontaneous recovery with this treatment. Severe cases may require care for several days. There are no known permanent effects. CAUTION— PERSONS WITH HEART PROBLEMS OR THOSE ON A 'LOW SODIUM' DIET OR INTAKE MUST CONSULT A PHYSICIAN ON WHAT TO DO UNDER THESE CONDITIONS.

Heat Stroke

Heat stroke is the most serious of the health problems which can arise while working in hot environments. It occurs when the human thermo-regulatory system simply breaks down under stress, and sweating stops. There may be little warning to the victim that a crisis stage has been reached. Just why this happens is not known, but when it does, the body's only effective means of getting rid of excess heat is gone.

A heat stroke victim's skin is hot, dry, and usually red or spotted. Body temperature is 40·5°C or higher and rising. He or she is mentally confused, irritable and may complain of feeling chills. If the worker is not taken out of the hot environment at this early stage of heat stroke and cooled off rapidly, then more severe symptoms will occur, such as unconsciousness, delirium, and convulsions, leading to death.

An ambulance should be summoned immediately, but first aid is also vital. The worker should be taken to a cool area, his or her clothes thoroughly soaked with water, and the body vigorously fanned to increase cooling. Further treatment at a medical facility will continue the cooling process and monitor for a variety of complications which may accompany the disorder. Early recognition and treatment of heat stroke after it occurs are the only means of preventing permanent brain damage or death. Good physical fitness and heat acclimatization will increase a person's heat tolerance, but they will not give immunity against heat stroke. Those suffering from chronic disease, the obese, and the alcoholic are more susceptible. The person who has prior history of heat illness is also more prone to get this heat illness again.

Résumé

La température du corps doit être maintenue dans une marge étroite si l'on veut éviter une détérioration des fonctions. La santé et même la vie peuvent être mises en danger par une hausse de la température interne ou centrale du corps. Le maintien de la température du corps dépend d'un équillibre entre la quantité de chaleur perdue et la quantité de chaleur produite par l'organisme plus la chaleur obtenue de l'environnement. Les pratiques de travail décrites dans ce document affectent l'une ou plusieurs de ces variables de la régulation thermique.

On y traite des avantages de caractéristiques individuelles comme la forme physique et l'adaptation à une atmosphère surchauffée, ainsi que des facteurs importants dont il faut tenir compte pour établir les périodes de travail et de repos.

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Book Review

The Costs of Uncertainty: Regulating Health and Safety in the Canadian Uranium Industry. Working Paper No. 24

Ian Robinson,
Centre for Resource Studies,
Queen's University,
Kingston, Ontario.

This study examines the policy implications of current issues and problems related to mineral resources in Canada. It was prepared under the supervision of Professor Richard Simeon of the Institute of Intergovernmental Relations, and jointly sponsored by the Institute of Intergovernmental Relations and the Centre for Resource Studies.

Federalism and, particularly, federal provincial jurisdictional relationships have led to considerable uncertainty in the regulation of occupational health and safety and of environmental protection in the Canadian uranium mining industry. Much needed reforms have been prevented by the federal/provincial conflicts over the constitutional rights of each level to regulate in this sector. The recommended changes include the following:

1. The Atomic Energy Control Board should withdraw from the regulation of all aspects of occupational health and safety and environmental protection in the uranium mining sector;
2. A system of concurrent jurisdiction, modelled on that which already exists for environmental protection in other sectors should be established;
3. Federal line departments (Labour, Environment) should set minimum national standards for both conventional and radiological hazards in occupational health and safety and environmental protection;
4. Provincial line departments should be free to introduce more stringent regulations if they wish, and should be responsible for the monitoring and enforcement of all regulations;
5. These changes should be effected through amendments to the 1946 Atomic Energy Control Act.

The Natural Resources Sector promises to be the focus of intense intergovernmental conflict and negotiation in the coming decade. Anything that can be done to resolve

this particular regulation issue may therefore help to ease the pressures in the larger context and, at the same time, bring about needed improvements in the standards of occupational and environmental protection in the uranium mining industry.

Peter L. Pelmear

Publications Available from the Government Book Store

Publications under the Regulation Act vol. 112-39	
Revised Regulations of Ontario, 1980 Regulation 692/80 Industrial Establishments	$2.00
Revised Regulations of Ontario, 1980 Regulation 691/80 Construction Projects	$2.00
Revised Regulations of Ontario, 1980 Regulation 694/80 Mines and Mining Plants	$2.00
Regulations respecting Lead — made under the Occupational Health and Safety Act Ontario Regulation 536/81	$1.00
Regulation respecting Mercury — made under the Occupational Health and Safety Act Ontario Regulation 141/82	$1.00
Regulation respecting Vinyl Chloride — made under the Occupational Health and Safety Act Ontario Regulation 516/82	$1.00
Regulation respecting Coke Oven Emissions — made under the Occupational Health and Safety Act Ontario Regulation 517/82	$1.00
Regulation respecting Asbestos — made under the Occupational Health and Safety Act Ontario Regulation 570/82	$1.00
An Occupational Health Nurse's Guide to the Preparation of a Policy and Procedure Manual	$2.00
A Guide to The Occupational Health and Safety Act, 1978	$1.00

News and Notes

Queen's University, Kingston

The Queen's University Occupational Health and Safety Resource Centre is offering a training course in Industrial Audiometry and Hearing Conservation, April 18-20, 1983. This course has been designed to meet the Ministry of Labour's recommendations for appropriate training of audiometric technicians in industry. Students are recruited from among occupational health nurses and safety technicians, but those who supervise occupational health and safety programs would also benefit from the course. On successful completion of the course, students should have a knowledge of the concepts of hearing conservation, an understanding of the physical measurement of sound and the practical ability to undertake competent audiometry. They will also be aware of the ethical and legal considerations surrounding audiometry and be familiar with record keeping techniques. For further information, contact the Occupational Health and Safety Resource Centre, Queen's University, 25 Union Street, Kingston, Ontario, K7L 2N6.

Academy of Medicine Occupational Health Section, 288 Bloor St. West, Toronto, Ontario Phone: 922-1134

Thursday, May 5, 1983 - Academy of Medicine, Toronto - 5:30 p.m. Meeting on the Psychotic and Employment - Medical Legal aspects by Aubrey Golden, Labour Lawyer, with presentations by Dr. Elizabeth Kaegi and Dr. J. Nethercott.

Thursday, June 2, 1983 - Academy of Medicine, Toronto - 6:30 p.m.: Cocktails; 7:00 p.m.: Dinner; 8:00 p.m.: Meeting on the Relationship of Anthropology to Occupational Health, by Dr. William Swinton, Past Curator of the British Museum.

Advance notice of attendance for dinner is required by the Academy.

International Conference on Occupational Ergonomics

In Canada, the United States and Europe there is an increasing interest in the application of ergonomics. Ergonomics is the application of life science knowledge about human characteristics to maximize well-being and performance. Two current pressures motivating this interest are troubled economics and the increasing concern for occupational health and safety.

With these issues in mind, the Human Factors Association of Canada and the International Ergonomics Association will be holding a joint conference in Toronto in May 1984.

Objectives

1. To increase awareness of industrial applications of ergonomics among the research and occupational communities.
2. To increase interaction between users and providers of ergonomic information.
3. To increase awareness of human factors common to different occupations.
4. To upgrade the skills of professionals in ergonomics.

Topics

Topics include:

Back Stress	Office Ergonomics	Health Care
Shiftwork	Tool and Equipment Design	Transportation
Mining		Aging
Clothing	Quality Control	Forestry
Vibration	Systems Modelling	Training
	Human Reliability	

Location

The Toronto Harbour Castle Hilton Hotel has been reserved for May 7, 8 and 9, 1984.

Call for Papers

A call for papers will be issued in March 1983. More detailed information on the conference is available from:

Conference Chairman: Dr. E.S. Gibson
P.O. Box 1085, Station B,
Rexdale, Ontario,
Canada M9V 2B3
Tel. (416) 675-2235

Workers At Risk

Series 6 x 15 minutes.
Colour videotape.

What constitutes a hazard? The series *Workers At Risk,* produced with the co-operation of the Occupational Health and Safety Division of Alberta Workers' Health, Safety and Compensation, exposes potential dangers lurking on the job. By examining the personal attitudes and actions of workers, these informative docu-dramas demonstrate the cause and effect characteristics of career-related accidents. Health and safety is presented as a variable within the worker's control as the legal and moral responsibilities and rights of membership in the work-place are discussed. Clear illustrations and non-technical language help the viewer to identify how he/she may be creating or fostering possible hazards. The realistic characters and situations portrayed in *Workers At Risk* will entertain audiences, as well as promote expanded perceptions of the worker's role in preventing and controlling on-the-job risks.

01 You Bet Your Life
02 It's All In Your Head
03 Those Other Guys
04 That's A Killer
05 Why Not Live?
06 Who's Responsible?

Availability: This series is available from the ACCESS Media Resource Centre. For further information please contact:

ACCESS Alberta
16930 - 114 Avenue
Edmonton, Alberta
T5M 3S2
Telephone: (403) 451-3160

ACCESS Media Resource Centre
Calgary Health Sciences Centre
3350 Hospital Drive N.W.
Calgary, Alberta T2N 4N1
Telephone: (403) 283-8241

Grant Programs for Studies Related to the Reduction of Occupational Back Problems

The Council of Safety Associations announces the availability of grants for studies and research. Up to $10,000.00 of funding can be obtained for this year with further grants being possible in subsequent years upon re-application.

These grants are not intended to fund programs, people or equipment. They are designed to aid the collection of relevant data on the effectiveness of different approaches for the reduction of occupational back problems. Possible research or study areas would include pre-employment assessment, fitness, education, job design and ergonomics.

Preference will be given to studies with general application to a significant portion of the working population. Applicants must demonstrate that good research principles will be incorporated in the study.

Application forms are available from:

Council of Safety Associations
Task Force on Backs
23rd Floor
2 Bloor Street East
Toronto, Ontario
M4W 3C2

Deadlines for applications are June 1 and December 1, 1983. Applicants will be reviewed by the Council's Task Force on Backs.

Second International Conference on Carbonaceous Particles in the Atmosphere

The conference will take place September 11-14, 1983, in Linz, Austria.

For further information, contact the conference secretary:

H. Puxbaum,
Institute for Analytical Chemistry,
Technical University of Vienna,.
Getreidemarkt 9,
A-1060 Wien, Austria.

11th Annual Conference of the Association for Aerosol Research

September 14-16, 1983, in Munich. The host and co-organizer of this year's meeting is: Gesellschaft fuer Strahlen - und Umweltforschung, Muenchen, Prof. Dr. W. Jacobi and Prof. Dr. W. Pohlit.

Papers read at the conference will be published in the *Journal of Aerosol Science.*

As in previous years, manufacturers of aerosol equipment, and other interested parties, will have the opportunity to demonstrate and advertise their products in an exhibition.

For details, please contact the Secretary General.

Canadian National Congress of Occupational Medicine

The first Canadian National Congress of Occupational Medicine will be held November 9, 10 and 11, 1983 in The Westin Hotel, Toronto, under the auspices of the Canadian Council of Occupational Medicine. The annual meetings of the Canadian Council and the Canadian Board of Occupational Medicine will be held concurrently. This Congress is the outcome of more than 40 years of meetings of occupational physicians held on alternate years in the provinces of Ontario and Quebec.

The Canadian Council welcomes membership from any physician in Canada, having an interest in the field of occupational medicine. Such physicians are welcome at the forthcoming meeting.

For further information, contact:

Douglas R. Warren, MD. DPH, CCBOM
Executive Secretary
Canadian Council of Occuaptional Medicine, and
Canadian Board of Occupational Medicine
7th Floor
290 Yonge Street
Toronto, Ontario
M5B 1C8

Coming Events

May 8-13, 1983	10th World Congress on the Prevention of Occupational Accidents and Diseases, Ottawa, Ontario, Canada.
May 16-18, 1983	Cancer in the Workplace, International Conference. The University of British Columbia, Vancouver, British Columbia, Canada.
May 22-27, 1983	American Industrial Hygiene Conference, Philadelphia, PA, U.S.A.
June 14-15,1983	IAPA/OHAO: Health Hazards in the Workplace: Assessment and Control, Toronto, Ontario, Canada.
June 21-25, 1983	Noise as a Public Health Problem. Fourth International Congress, Turin, Italy
July 11-15, 1983	Society of Occupational Medicine Annual Provincial Meeting, Portsmouth, U.K.
July 12-14, 1983	Ultrasonics International '83, Dalhousie University, Halifax, Nova Scotia, Canada.
July 19-22, 1983	Second International Conference on the Clinical Chemistry and Chemical Toxicology of Metals, Montreal, Quebec, Canada.
August 28-September 2, 1983	American Chemical Society Symposium on Chlorinated Diseases and Dibenzofurans in the Total Environment, II.
September 10-14, 1983	9th International Congress on Agricultural Medicine, Christchurch, New Zealand. Details from John Stoke, Deputy Director (Occupational Health), Division of Public Health, Department of Health, Macarthy Trust Building, Lambton Quay, Wellington, New Zealand.
September 11-14, 1983	Second International Conference on Carbonaceous Particles in the Atmosphere, Linz, Austria.

September 13-17, 1983	VI International Symposium on Occupational Health in the Production of Artificial Organic Fibres, Permanent Commission and International Association on Occupational Health, Mannheim, Federal Republic of Germany.
September 14-16, 1983	11th Annual Conference of the Association for Aerosol Research, Munich, Federal Republic of Germany.
September 20-23, 1983	VIth International Pneumoconiosis Conference, Ministry of Labour and Social Affairs of the Federal Republic of Germany, Bochum, Federal Republic of Germany.
September 26-29, 1983	Medichem '83. 11th International Congress on Occupational Health in the Chemical Industry. Calgary, Alberta, Canada.
October 18-20, 1983	Three-day International Conference on Offshore Safety and Health (ICOSH), Halifax, Nova Scotia, Canada.
September 5-10, 1984	XXI International Congress on Occupational Health, Dublin, Ireland.

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ISSN 0705-9388